Dec. 4, 1956 A. J. BAROCCA 2,772,633

ELECTRIC BLASTING CAP

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FIG. 1.

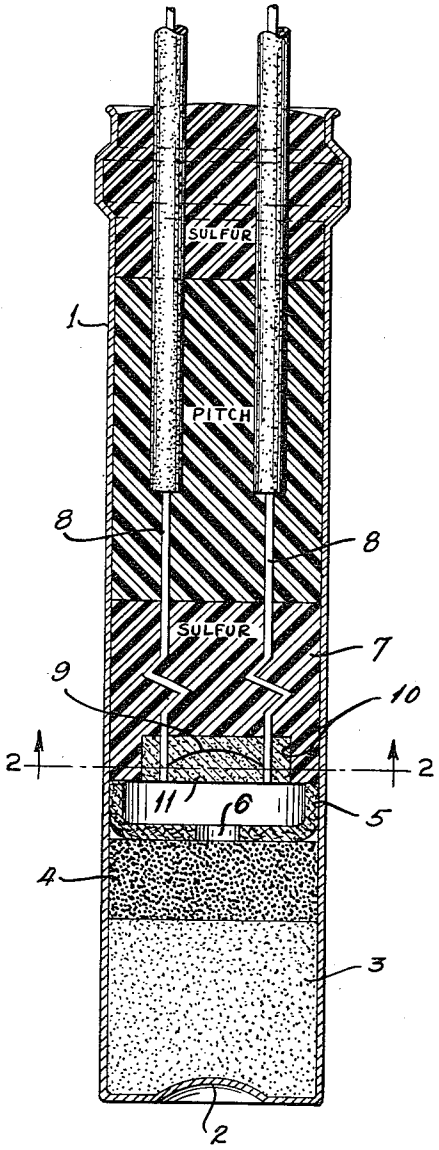
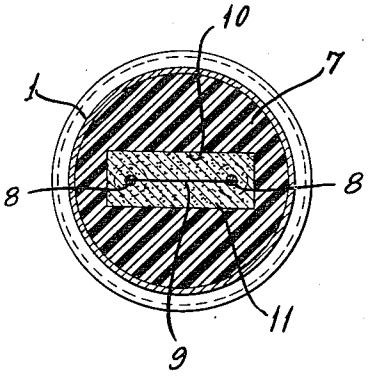


FIG. 2.



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ELECTRIC BLASTING CAP

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6 Claims. (Cl. 102—28)

This invention relates to heat-sensitized blasting caps and, more specifically, to the ignition charge of electric blasting caps adapted for seismographic exploration work. This application is a continuation-in-part of my prior copending application, Serial No. 22,280, filed April 21, 1948, and now abandoned.

In the conventional electric blasting cap, there is an explosive train usually consisting of three charges, to-wit: the igniter, the initiator, and the base charge. An electric current activates the igniter, which in turn activates the initiator, which in turn activates the base or detonating charge. The electric current is supplied to a high resistance filament, in contact with the ignition charge, so that the latter is ignited when the filament becomes heated to the proper temperature.

When electric blasting caps are destined to be used in ordinary commercial blasting operations, the time interval between the instant of application of the firing current and the instant of detonation is of little or no import. However, when the caps are used for rather special purposes, such as seismographic exploration, the degree of accuracy of the work is dependent upon knowledge of the instant of detonation. In the field, the instant of detonation must generally be derived from knowledge of the instant at which the firing current was applied. No accurate derivation can be made, however, unless the interval of time between the application of current and the detonation of the charge is either a known constant or is so small that it is substantially zero when measured with standard seismographic equipment. Generally, any interval of time of a millisecond or less can be considered as zero for practical purposes.

Some seismograph operators assume "zero time" or the instant of explosion to be simultaneous with the instant of current application. For their use then, a cap should have a total explosion time of one millisecond or less. Other seismograph operators assume "zero time" to be simultaneous with the rupture of the bridge wire and consequent interruption of the current flow as a result of the detonation. The latter would be a very convenient method of determining "zero time" if the bridge wire ruptured only as a result of the explosion. Such rupture may also result if the current passing through the bridge wire is of sufficiently high magnitude to fuse the wire before the detonation occurs. To minimize difficulties from leaking current in wet holes and salt water holes, and to make sure that a sufficient amount of energy is delivered to the cap, some operators pass as much as 15 to 20 amperes of current through the cap. This amount of current and even less (5 amperes) is sufficient to fuse the bridge wire. In such cases, the timing is in error by the difference in time between the fusing of the bridge wire and the detonation of the cap. In a "slow" cap, this difference may be considerable. It is thus evident that the art of seismographic exploration would be benefitted by the provision of an electric blasting cap whose explosion time was a dependable known constant, preferably less than a millisecond, from the instant of application of the firing current; and such is the general object of this invention.

The "explosion time" is the sum of two distinct factors, to-wit: "pulse time" and "lag time." "Pulse time" is the interval between initial application of the electromotive force and the instant whereat the ignition composition is ignited. "Lag time" is the interval between the instant at which the ignition charge is ignited and the instant at which explosion of the cap takes place. Thus "lag time" includes the burning period for the entire explosive train of the cap, to-wit: the ignition charge, the initiating charge, and the base charge.

The total "explosion time" (from the instant of application of the electromotive force to the detonation of the cap) may be physically measured with accuracy, but the instant of ignition of the ignition charge is not physically measurable. For any given cap, the instant of ignition is ascertained by applying a current of fixed magnitude for successively increasing distinct increments of time until detonation occurs. When detonation occurs, the mean between the effective time increment (which causes detonation) and the greatest ineffective time increment (which failed to cause detonation) is taken as the "pulse time." For example, a given blasting cap may be supplied with 2.5 amperes of current first for 0.5 millisecond, then re-energized at the same current for 0.6 millisecond, then for 0.7, 0.8, 0.9, 1.0 mililsecond, and so on until detonation occurs. If detonation did not occur after the 0.9 millisecond test, but did occur after the 1.0 millisecond test, then the mean between 0.9 and 1.0 is taken as the "pulse time." The balance of the measured "explosion time" is the "lag time."

The "pulse time" is dependent upon a number of variables. Thus it may vary with the length of the bridge wire, the diameter of the bridge wire, the internal resistance of the bridge wire, and also with the amperage of the firing current in addition to the nature and condition of the ignition composition.

The "lag time" is relatively independent of the nature of the bridge wire, but depends almost entirely on the nature and condition of the ignition composition surrounding the bridge wire. Thus blasting caps containing mercury fulminate, lead sulfocyanate, etc., as igniters, may be considered as "slow" caps, while caps containing lead trinitrorescorcinate as the igniter are classed as "fast caps." The utility of lead trinitroresorcinate as an igniter in blasting caps for seismographic exploration has been suggested in United States Patent No. 2,086,530 to Burrows. It has now been learned, however, that, although lead trinitroresorcinate has an inherently short "lag time," it is not dependable as an igniter in blasting caps wherein a brief "lag time" is essential. This is due to the fact that the "lag time" of lead trinitroresorcinate in a blasting cap ignition system is usually low, less than 1 millisecond; but that a small but definitely significant proportion, approximately 6%, of blasting caps provided with an igniter of lead trinitroresorcinate exhibited "lag times" well in excess of 1 millisecond. In fact, values of approximately 3 milliseconds have been recorded for such blasting caps. Variations of this nature result in grievous error in seismic operations; and tend to refute the reliability of each individual cap which is ignited by lead trinitroresorcinate alone.

The object of this invention is the provision of a blasting cap with an ignition composition having a uniformly and dependably "fast" firing time.

This and other objects are achieved in accordance with this invention by the utilization of ignition compositions containing lead trinitroresorcinate intermixed with either cyclotrimethylenetrinitramine or pentaerythritetetranitrate. The term "lead trinitroresorcinate," as used in this

specification and appended claims, includes the normal and basic lead trinitroresorcinates, as well as complex salts thereof, such as combinations of the trinitroresorcinates and hypophosphites of lead.

This invention is predicated upon the discovery that the erratic performance of lead trinitroresorcinate as an igniter is overcome by the addition thereto of either cyclotrimethylenetrinitramine or pentaerythritetetranitrate. With such a mixture, lag times of one millisecond or less are consistently obtainable. The proportions of ingredients in such an ignition composition may vary widely and are desirably within the following ranges: 25% to 90% lead trinitroresorcinate and 75% to 10% cyclotrimethylenetrinitramine; 50% to 90% lead trinitroresorcinate and 50% to 10% pentaerythritetetranitrate.

An electric blasting cap embodying the invention is shown in the accompanying drawings wherein:

Figure 1 is a longitudinal sectional view of the complete cap; and

Figure 2 is a sectional view taken along line 2—2 of Figure 1.

The cap shown in the drawing consists of a tubular casing **1** having an integral closed end **2**. Adjacent the end **2**, a base charge **3** is loaded. Such a base charge may consist of any explosive usually employed for the purpose, such as tetryl, cyclotrimethylenetrinitramine, pentaerythritoltetranitrate, picric acid, trinitrotoluene, or mixtures thereof; for example, 6.0 grains of tetryl may be pressed in the end of the casing under 160 pounds dead weight. Above the base charge **3**, an initiating charge **4** is applied. The latter may be any of the primary explosives (highly sensitive to flame and/or shock) usually employed for the purpose, such as lead azide or mercury fulminate; for example, 3 grains of lead azide pressed in situ under 180 pounds dead weight. Above the charge **4**, a spacer **5** in the form of a fiber cup with a central perforation **6** is arranged. Thereabove, a plug **7** containing embedded lead wires **8** is inserted. The termini of the wires **8** are bridged by a resistance filament **9**, which is disposed within a cavity **10** in the lower face of plug **7**. The cavity **10** contains the igniter composition **11** in intimate contact with bridge wire **10**. The casing **1** is filled (above plug **7**) with suitable sealing and anchoring materials in accordance with the usual practice.

In accordance with the preferred embodiment of this invention, the ignition composition **11** consists of substantially equal portions (by weight) of lead trinitroresorcinate and cyclotrimethylenetrinitramine. The two ingredients are thoroughly mixed dry, and water, is then added until the composition has a consistency such that it may be readily charged into, and retained by, cavity **10**. The addition of a small amount of a water soluble gum, such as gum arabic or gum tragacanth, to the water of suspension serves well to provide a mix having advantageous cohesive and adhesive properties. The plugs containing the wet ignition composition are freed from water by drying at 60° C., dipped in a 2% nitrocellulose lacquer, and redried.

Other examples involve varying the relative proportions of lead trinitroresorcinate and cyclotrimethylenetrinitramine as follows:

(1) One part lead trinitroresorcinate with three parts cyclotrimethylenetrinitramine.

(2) Three parts lead trinitroresorcinate with one part cyclotrimethylenetrinitramine.

(3) Nine parts lead trinitroresorcinate with one part cyclotrimethylenetrinitramine.

All these variants are productive of uniformly short lag times without the objectionable frequency of erratic long lag time which characterizes lead trinitroresorcinate when used alone as the ignition composition.

The above examples merely serve to illustrate the invention and are not to be construed as limiting the invention in any respect. The invention is equally well adapted to blasting caps wherein the ignition composition is suspended on the bridge wire in the form of a bead and also to blasting caps having a loose ignition composition surrounding the bridge wire.

A series of one hundred electric blasting caps constructed and loaded as described in the first example above (charged with an ignition mixture composed of equal parts of lead trinitroresorcinate and cyclotrimethylenetrinitramine) was subjected to test with the following results (time expressed in milliseconds; caps activated with 2.5 amperes):

	Explosion Time	Pulse Time	Lag Time
Average	0.7	0.5	0.2
Maximum	1.0	0.8	0.4

A test of a series of caps charged with lead trinitroresorcinate (without cyclotrimethylenetrinitramine) as the igniter, but otherwise identical with the caps of the foregoing test, showed 6.5% of the individual caps to have lag times of one millisecond or more. Identical caps charged with cyclotrimethylenetrinitramine (without lead trinitroresorcinate) as the igniter fail to detonate although current be maintained at a magnitude and for a time sufficient to fuse the bridge wires. The failure of cyclotrimethylenetrinitramine to respond to the heated bridge wire was not unexpected because cyclotrimethylenetrinitramine has not been regarded as heat-sensitive to an extent such as to render it useful as the igniter in an electric blasting cap.

As another example of this invention, the ignition composition **11** may consist of substantially 75 parts by weight lead trinitroresorcinate and about 25 parts pentaerythritoltetranitrate. The two ingredients are thoroughly mixed, dried and the water is then added until the composition has a consistency such that it can be readily charged into, and retained by, cavity **10**. A small amount of water soluble gum, such as gum arabic or gum tragacanth, may be added to the water suspension to provide a mix having advantageous cohesive and adhesive properties. The plugs containing the wet ignition composition are freed from water by drying at 60° C., dipped in a 2% lacquer and redried.

A series of twenty-five electric blasting caps constructed as described above and charged with the ignition mixture last above described, when subjected to the test above described, gave the following results:

	Explosion Time	Pulse Time	Lag Time
Average	1.6	1.4	0.2
Maximum	2.0	1.8	0.5
Minimum	1.1	1.0	0.0

Thus, while the pulse time is longer than in the case of the lead trinitroresorcinate-cyclotrimethylenetrinitramine caps, the lead trinitroresorcinate-pentaerythritoltetranitrate mixture is nonetheless suitable for the purpose because the spread between maximum and minimum is less than one millisecond and hence the average value may be confidently relied upon for practical purposes.

Other compositions consisting essentially of lead trinitroresorcinate and pentaerythritoltetranitrate and containing amounts of pentaerythritoltetranitrate from about 10 parts to about 50 parts per 100 parts by weight are suitable for the purpose. Best results are obtained with compositions containing from about 10 to 25 percent by weight PETN and the balance lead trinitroresorcinate with about one percent of gum.

While the synergetic action of cyclotrimethylenetrinitramine and PETN on lead trinitroresorcinate, whereby erratic prolonged lag times are substantially eliminated, cannot be theoretically explained, it has been proven in

practice, and hence may be regarded as catalytic in character. The short, uniform, and dependable "lag times" resulting from the present invention provide for greater accuracy and more reliable data in seismic operations.

Although the invention has been particularly described in its relation to seismic operations, it is evident that the ignition composition of this invention may also be used with equal success in ordinary blasting caps and with any explosive train utilizing a heat-sensitive ignition composition.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. In an electric blasting cap having an electric heating element and an ignition composition in contact with said element, said composition comprising a substantial amount of lead trinitroresorcinate intimately mixed with a substantial amount of cyclotrimethylenetrinitramine.

2. The blasting cap as claimed in claim 1 wherein the ignition composition comprises 25 to 90 percent lead trinitroresorcinate and 75 to 10 percent cyclotrimethylenetrinitramine.

3. The blasting cap as claimed in claim 1 wherein the ignition composition consists essentially of substantially equal parts of lead trinitroresorcinate and cyclotrimethylenetrinitramine.

4. In an electric blasting cap having an electric heating element and an ignition composition in contact with said element, said composition comprising a substantial amount of lead trinitroresorcinate intimately mixed with a substantial amount of an explosive selected from the class consisting of cyclotrimethylenetrinitramine and pentaerythritoltetranitrate.

5. The blasting cap of claim 4 wherein the ignition composition comprises 50 to 90 percent lead trinitroresorcinate and 50 to 10 percent pentaerythritoltetranitrate.

6. The blasting cap of claim 4 wherein the ignition composition consists essentially of substantially three parts of lead trinitroresorcinate per part of pentaerythritoltetranitrate.

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